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COVER LETTER

Professor Robert Ruben

Editor-in-Chief, *International Journal of Pediatric Otorhinolaryngology*

Albert Einstein College of Medicine,

Bronx, New York,

USA

2 June 2015

Dear Prof. Ruben,

We wish to submit our manuscript entitled “Surgery for Velopharyngeal Insufficiency: the outcomes of the University Hospitals Leuven” to be considered for review by the *International Journal of Pediatric Otorhinolaryngology (*IJPORL*)*.

This paper describes our evidence with the Honig velopharyngoplasty and the modified Honig velopharyngoplasty as efficient techniques to correct velopharyngeal insufficiency.

IJPORL has published many articles related to the treatment of velopharyngeal insufficiency and we believe our findings will be of high interest to the readers of your journal.

We wish to confirm that there are no known conflicts of interest associated with this publication.

Possible scientists who might be interested in reviewing this manuscript are:

1.Kathleen Sie, kathleen.sie@seattlechildrens.org, pediatric ENT doctor

2. Nathalie Bernheim, Nathalie.bernheim@huderf.be, pediatric ENT doctor

We hope you find our manuscript suitable for publication and look forward to hearing from you.

Yours sincerely,

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*Title Page

ORIGINAL ARTICLES

Surgery for Velopharyngeal Insufficiency: the outcomes of the University Hospitals Leuven

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The manuscript was presented at the Annual Congress of the Royal Belgian Society of Otorhinolaryngology, Head and Neck Surgery in Brussels on March 23th 2013.

Conflict of interest: The authors declare that they have no conflict of interest.

ABSTRACT

Objectives: The outcomes of 91 patients who underwent a velopharyngoplasty and subsequent speech therapy for velopharyngeal insufficiency (VPI) were reviewed to determine possible prognostic variables.

Design: This was a retrospective chart review of 91 consecutive patients over 8 years (2002 to 2010). Variables analyzed include age at the time of velopharyngoplasty, associated 22q11.2 deletion syndrome, intervention type, primary or secondary surgery and pre-intervention speech therapy.

Methods and Materials: The different types of interventions were the (modified) Honig velopharyngoplasty and the Hynes pharyngoplasty. Five criteria were evaluated pre- and postoperatively, hypernasality, nasal emission, facial grimacing, retro-articulation and glottal stops. The former two variables were transformed into a semi-objective nasality index (NI). The latter three variables were assembled to form a subjective articulation index (AI).

Results: Before surgery, 15 patients had mild VPI and 44 patients had moderate to severe VPI, in accordance with the nasality index. Postoperative outcomes at 12 months showed that 46 patients had good results (normal or mild VPI) and 13 patients had moderate VPI. No patients had severe VPI postoperatively. The overall success rate of 78% after one year, increased to 90% in the long-term (median 27 months). Patients with the diagnosis of 22q11.2 deletion syndrome had worse speech after surgery than patients without the syndrome. No statistically significant effect of the age at the time of velopharyngoplasty on speech outcome was found. No cases of sleep apnea syndrome were reported.

Conclusions: The Honig velopharyngoplasty and the modified Honig velopharyngoplasty are efficient techniques to correct velopharyngeal insufficiency.

Key Words: cleft palate; 22q11.2 deletion syndrome; velopharyngeal insufficiency; velopharyngoplasty; speech

VELOPHARYNGEAL INSUFFICIENCY is the inability to completely close the velopharyngeal port during speech production or feeding. It results from a discrepancy of velar length versus the depth of the nasopharynx, or from insufficient lifting of the velum towards the posterior pharyngeal wall. This insufficiency may provoke excessive nasal resonance (hypernasality), escape of air through the nose while speaking (nasal emission), unclear or distorted articulation, aberrant facial movements during speech (facial grimacing) or nasal regurgitation of food and liquids.[1.2] The unclear or distorted articulation can be explained by the inability to increase the intra-oral air pressure that is required for the formation of several consonants (in particular the plosives like /p/, /t/ and /d/). As a compensation, patients may form sounds more in the back of the throat: /k/ and /g/. This is called retro-articulation. Oral plosives may also be substituted by glottal stops, as the glottis is the only point in the vocal tract where the child can achieve an increase in air pressure. Facial grimacing is the use of the nasal or facial muscles in an attempt to prevent the escape of air through the nose. A variety of factors may cause VPI, the most common being an overt or submucous cleft of the soft palate.[2]

If hypernasality persists after primary repair of the cleft palate and after intensive speech therapy, surgery is indicated to improve velopharyngeal function. A large number of surgical techniques are described to address VPI. These can be grossly divided in palatoplasties (aimed at increasing the length and/or the mobility of the palate), pharyngoplasties (aimed at decreasing the velopharyngeal space) and palato-pharyngoplasties (a combination of both).[3] In the University Hospitals Leuven, the conventional Honig velopharyngoplasty and the modified Honig procedure were the most common surgical procedures to treat VPI between 2002 and 2010. Both techniques combine palatal lengthening by retropositioning the velum, with the insertion of a pharyngeal flap. The modification can be found in the type of palatal flap used for retropositioning, with the conventional Honig velopharyngoplasty using full thickness mucoperiosteal flaps for the oral lining of the defect and the modified Honig procedure using mucosal (supraperiostal) flaps, thus preserving the periosteum and the palatine artery.[4]

The used pharyngeal flap is a superiorly based midline myomucosal flap from the posterior pharyngeal wall (superior pharyngeal constrictor fibers and horizontal fibers of the palatopharyngeal muscle). The flap is inserted to the nasal side of the posterior border of the hard palate, creating a midline obstruction of the oral and nasal cavities with 2 lateral velopharyngeal openings, or ports.

In 2007, the Hynes procedure was introduced in our hospital.[5] The goal of this procedure is to augment the posterior pharyngeal wall and thus to diminish the velopharyngeal gap. This is accomplished by transposing bilateral superiorly based myomucosal flaps, raised from the lateral pharyngeal walls, to the posterior pharyngeal wall and to each other.

Primary closure of the donor defect also approximates the horizontal fibers of the palatopharyngeal muscles.

The Hynes technique was used for persistent mild VPI despite reaching the maximum outcome of speech therapy , due to a relatively small velopharyngeal defect in the presence of a good, posterior position of the levator sling.

The aim of this study was to evaluate the results of correction of VPI using a conventional Honig velopharyngoplasty, a modified Honig velopharyngoplasty or a Hynes procedure and the postoperative speech therapy course. A chart review was performed of the pre- and postoperative speech analyses of patients who underwent one of this procedures in our institution. A distinction was made between patients with and patients

without 22q11.2 deletion syndrome. The relation to possible prognostic variables (intervention type, age at surgery, primary or secondary surgery and the duration of pre-intervention speech therapy) was also explored.

PATIENTS

The records of all patients who underwent a conventional Honig velopharyngoplasty, a modified Honig velopharyngoplasty or a Hynes pharyngoplasty for VPI in our hospital between 2002 and 2010 by one senior surgeon (V.V.) were reviewed. The group consisted of 91 consecutive patients. Of 29 patients one or more data were missing, reducing the study population with complete records to a group of 62 patients, 30 females and 32 males. The average age at the time of surgery of this last group was 10 years (127 months), ranging from four to 46 years of age. The velopharyngeal insufficiency was due to a submucous cleft palate (16), a cleft palate (12), a congenital short velum (11), unilateral complete cleft lip and palate (9), bilateral complete cleft lip and palate (6), or followed adenoidectomy and/or tonsillectomy (8) (Figure 1). Fourteen patients were known with 22q11.2 deletion syndrome (of which six had a submucous cleft and one had a cleft palate – the others had VPI due to hypo- or atonia of the muscles). All patients with VPI due to a congenital short velum and VPI following adenoidectomy and/or tonsillectomy underwent a primary velopharyngoplasty, as did 12 patients with VPI due to a submucous cleft palate, and 2 patients with VPI due to a cleft palate. The remaining 29 patients underwent a secondary velopharyngoplasty of which 21 patients underwent the primary surgery in another hospital (Figure 1).

Of the 91 studied patients, one or more data were missing in 35 patients for the NI and in 32 patients for the AI. Median follow-up was 17 months, the range being 8 – 79 months.

METHODS

All patients underwent a preoperative screening which included a clinical examination, a perceptual speech investigation and a videofluoroscopy.

The oto- rhino- laryngological examination consisted of a mouth and throat inspection and a nasendoscopy when tolerated, to examine the length and the mobility of the velum, the orientation of the velar musculature and the appearance of the uvula. In case of a suspected submucous cleft palate, a palpation of the edge of the hard palate was performed.

A standardized perceptual speech investigation was performed by a speech and language therapist and consisted of a nasality and an articulation screening. Nasality assessment consisted of a semi-quantitative rating of hypernasality and nasal air emission using a standardized set of sounds and words.[6,7] A resulting score from 0-3 was attributed to every item using a semi-objective interpretation of the magnitude of the moist area on the ‘Czermak cold mirror test’ with zero indicating a good velopharyngeal closure and three a poor closure. A mean value of the summed scores on the subitems reflects the severity of nasality. This score is called the semi-objective NI and ranges from 0 (undetectable hypernasality) over 1 (mild hypernasality), 2 (moderate hypernasality) to 3 (severe hypernasality).

The articulation screening detected compensatory mechanisms like retro-articulation, glottal stops and facial grimacing. A phonetically balanced word list was used to assess these items: retro-articulation (present = 1; or absent = 0), glottal stops (pharyngeal fricatives or glottal stops present = 1; or absent = 0) and facial grimacing (present = 1; or absent = 0).[6] These three articulation errors were combined to form the subjective AI. For every finding present, one point was attributed, thus resulting in a score ranging from 0 (no VPI-related articulation errors) to 3 (all 3 items present).

The first surgical technique used in 24 patients was a conventional Honig velopharyngoplasty, where a lengthening of the velum is obtained by retropositioning of a full thickness mucoperiosteal flap from the hard palate, associated with a superiorly based pharyngeal flap.[4] This flap (mucosa, submucosa and constrictor pharyngis superior muscle with some horizontal part palatopharyngeus fibres) is elevated off the prevertebral fascia to a level well above the corpus of the atlas bone, and sutured to the nasal side of the posterior border of the hard palate. The defect at the level of the posterior pharyngeal wall is primarily closed. The soft palate is incised in the sagittal midline from the uvula toward the junction and hard palate. A Wardill incision is then made, with subsequent development of flaps, including the mucous membranes, the submucous layer and the periosteum. The hamulus of the processus pterygoideus is bilaterally fractured followed by maximal retropositioning of the flap. The velar muscles are moved posteriorly in the process and the muscles of both sides are sutured on the midline.

The second surgical technique, used in 34 patients, was a modified Honig procedure. This is a supraperiosteal velar retropositioning procedure, associated with a pharyngeal flap. This supraperiosteal technique leaves the periosteum and the neurovascular bundle with the greater palatine artery intact on the palatal shelves.[4]

The third surgical technique, used in four patients, consisted of a Hynes procedure.[3,8] Hereby, two lateral superiorly based myomucosal flaps are created from the posterior tonsillar pillars (palatopharyngeus muscle). The flaps are transposed 90 degrees to the contralateral side and are inserted into the posterior pharyngeal wall above the corpus of the atlas in an overlapping side-to-side fashion. Invariably, the soft palate is incised in the sagittal midline for a good exposure of the posterior pharyngeal wall for flap inset.

Postoperative care consisted of overnight monitoring with pulse oximetry. Most patients were discharged from the hospital after three nights. The postoperative policy consisted of antibiotic treatment (amoxicilline) and decongestive nose drops during one week, adequate analgesia and adjustment of the diet (liquid nutrition during one week followed by a diet of soft foods for four weeks). Patients were seen four weeks after surgery for a follow-up evaluation. Speech therapy resumed two months after surgery to unlearn the compensatory articulation errors and to learn how to use the new anatomical situation properly. Postsurgical velopharyngeal assessment was performed at two and 12 months postoperatively and consisted of a perceptual speech evaluation by the speech and language therapist.

STATISTICAL ANALYSIS

Statistical analysis was performed using SAS software version 9.2 (SAS Institute Inc, Cary, North Carolina). Comparison between the preoperative, early postoperative and late postoperative results for the nasality and articulation index was performed using the Wilcoxon matched pairs signed ranks test. A nonparametric method was used to compare the preoperative and postoperative results because the dependent variable was ordinal. Comparison between the data of the VCFS group and the non-VCFS group was performed using the proportion odds logistic model. This model was also used for the analysis of the variable age at surgery and to determine whether primary surgery has better results than secondary surgery. This proportional odds regression model was used to analyze the difference between groups in postoperative ordinal scores including the preoperative score as a categorical variable. We wanted to analyze whether the duration of the preoperative speech therapy had an influence on postoperative outcomes, however, the sample size per group was too small to perform statistical testing.

A level of P < 0.05 was accepted as statistically significant.

RESULTS

ANALYSIS OF VELOPHARYNGEAL FUNCTION: HYPERNASALITY

In the patient group with complete data, 18 patients (25.4%) were rated as mildly hypernasal preoperatively, 33 patients (55.9%) presented with moderate hypernasality and 11 patients (18.7%) presented with severe hypernasality (Figure 2).

Two months postoperatively, 15 of 59 patients (25.4%) achieved a normal resonance. Of the remaining patients, 20 patients (33.9%) were rated as mildly hypernasal, 21 patients (35.6%) as moderately hypernasal and three patients (5.1%) as severely hypernasal.

Twelve months postoperatively, 25 patients (42.4%) had normal resonance, 21 patients (35.6%) had mild hypernasality and 13 patients (22.0%) had moderate hypernasality. None of the patients remained severely hypernasal. A Wilcoxon matched pairs signed ranks test demonstrated a highly significant difference ($p < 0.0001$) between the preoperative data versus the early and late postoperative data and also between the early and late postoperative data ($p < 0.0001$).

Of the 13 patients with moderate hypernasality after twelve months, seven patients evolved to a mild VPI after an average of 27 months (between 18 and 36 months), four patients did not show progression and of two patients data after 12 months are missing.

ANALYSIS OF VELOPHARYNGEAL FUNCTION: ARTICULATION DISORDERS

Preoperatively, 14 patients (22.6%) had no specific VPI-related articulation disorder (AD), 22 patients (35.5%) had a mild articulation disorder (AI = 1), 18 patients (29.0%) had a moderate articulation disorder (AI = 2) and 8 patients (12.9%) had a severe articulation disorder (AI = 3) (Figure 2). Postoperative outcomes at two months showed that 25 patients (40.3%) had no AD, 15 patients (24.2 %) had a mild AD, 17 patients (27.4%) had a moderate AD and 5 patients (8.1%) had a severe AD. Postoperative outcomes at 12 months showed that 30 patients (48.4%) had no AD, 17 patients (27.4%) had a mild AD, 12 patients (19.4%) had a moderate AD and 3 patients (4.8%) had a severe AD. A Wilcoxon matched pairs signed ranks test demonstrated a highly significant difference ($P < 0.0001$) between the preoperative data versus the late postoperative data. A comparison between the preoperative and early postoperative data and between the early and late postoperative data demonstrated a significant difference ($p = 0.0018$, respectively $p = 0.0214$).

Of the 15 patients with a moderate or severe AI after twelve months, 8 patients evolved to a mild AI or a normalization after an average of 43 months (between 23 and 78 months), 6 patients did not show progression and of one patient data after 12 months are missing.

COMPLICATIONS

The main complications of velopharyngoplasty are hemorrhage and upper respiratory tract obstruction manifesting as hyponasality or sleep apnea.

91.9% of the operations proceeded without surgical complications. Two patients underwent revision surgery shortly after the operation, one due to a hemorrhage and another due to loosening of the anterior suture of the palatal flap. One patient underwent a re-intubation because of a CO_2 retention, presumably based on a postoperative swelling in a small mouth. Furthermore, one patient developed a small oronasal fistula which was surgically closed 7 months later and one patient was readmitted to the hospital 7 days after the intervention due to difficult swallowing and dehydration.

In our study population, two patients (3.2%) had a mild form of hyponasality before the operation. One of these patients evolved to a moderate hyponasality postoperatively and the other patient had normal nasal resonance postoperatively. Nine patients (14.5%) developed hyponasality at two months postoperatively, of which 7 patients a mild form and two patients a moderate form. At 12 months after the operation, 11 patients or 17.7% had a mild form of hyponasality and two patients or 3.2% a moderate form (Figure 3).

A retrospective review of the chart notes demonstrated that snoring was absent postoperatively in 40 patients or 64.5%, that snoring was reported following surgery but disappeared spontaneously after an average of 6 months (between one and 14 months) in 15 patients or 24.2% and that snoring remained present in 7 patients or 11.3%. Of this last group, four patients had a mild form of snoring without an impact during the day, one patient had retrognathia and two patients had a more pronounced form and underwent a polysomnography. The investigations showed that one patient had an isolated snoring and that the other patient only snored when sleeping on the back, which could not be explained by nasal blockage. Polysomnography was not systematically performed postoperatively in our patient population.

PROGNOSTIC FACTORS

We assessed the prognostic effect on outcome of (1) syndromic diagnosis, (2) age at surgery, (3) amount of presurgical speech therapy, (4) surgical technique and (5) primary surgery versus secondary surgery following previous cleft palate surgery with remaining VPI.

(1) Absence of 22q11.2 deletion syndrome predicts good outcome

Comparing the velopharyngeal function of patients with (n = 14) to patients without (n = 45) the 22q11.2 deletion syndrome, a difference is observed in the percentage of patients without hypernasality at 12 months postoperatively. In the non-22q11.2 deletion syndrome group, 55.6% of patients were without hypernasality, whereas in the 22q11.2 deletion syndrome group, no patients remained without hypernasality. Consequently, a clearly larger proportion (42.9%) of patients displayed moderate nasality in the 22q11.2 deletion syndrome group as compared to the non-22q11.2 deletion syndrome group (15.6%). In both groups there were no patients with severe hypernasality late postoperatively (Figure 4). A proportion odds logistic model was used to compare the VCFS with the non-VCFS group. Controlling for the preoperative NI, there was no significant difference between the 22q11.2 deletion syndrome group and the non-22q11.2 deletion syndrome group early postoperatively ($P = 0.1517$). However, at the late postoperative control we did find a statistical significant difference ($P < 0.0028$) for the NI in favour of the non-syndromic patients. In terms of articulation, the 22q11.2 deletion syndrome patients also did worse. In the 22q11.2 deletion syndrome group, 21.4% of the patients had no specific VPI-related articulation disorders at the late postoperative control, compared to 56.2% in the non-22q11.2 deletion syndrome group. The percentage of patients with a combination of two or three articulation disorders was 42.9% in the 22q11.2 deletion syndrome group as compared to 18.8% in the non-22q11.2 deletion syndrome group (Figure 5). A proportion odds logistic model demonstrated a significant difference between the 22q11.2 deletion syndrome group and the non-22q11.2 deletion syndrome group at the early postoperative control ($p = 0.0046$). The difference observed at the late postoperative control did not reach statistical significance ($p = 0.0644$).

(2) Age at surgery

To test whether velopharyngoplasty followed by speech therapy at a younger age results in

better speech outcomes as compared to surgery at a more advanced age, we used a proportion odds logistic model with age as a continuous variable, controlling for the preoperative score. Using this analysis, we were not able to demonstrate a significant difference at the early nor at the late postoperative control ($p = 0.1457$, respectively $p = 0.0926$).

(3) Amount of speech therapy received before surgical correction

To test whether extensive pre-operative speech and language therapy positively affects outcome after velopharyngoplasty, we checked the correlation between the number of preoperative speech therapy sessions and the nasality index. However, the sample size per group was too small to perform statistical testing.

(4) Primary versus secondary surgery

We compared the results of the patients who underwent a primary velopharyngoplasty versus these undergoing a secondary salvage velopharyngoplasty after previous insufficient cleft palate surgery (Figure 6). A proportion odds logistic model was used to compare these two groups. Controlling for the preoperative score, there was a significant difference at the early and late postoperative control for NI ($p = 0.0473$, respectively $p = 0.0300$) with better outcomes in the secondary velopharyngoplasty group. We did not find a statistically significant difference for the articulation index.

(5) the used technique

We compared the results of the patients who underwent a Honig velopharyngoplasty ($n = 55$) with the results of the patients who underwent a Hynes pharyngoplasty ($n = 4$). When comparing the velopharyngeal function, we found that 40.0% of the patients who underwent a Honig velopharyngoplasty displayed normal resonance at the late postoperative control, 36.4% displayed a mild nasality, and 23.6% displayed a moderate nasality. In the Hynes group, 3 patients (75%) had normal resonance and one (25%) was mildly hypernasal at the late postoperative control. When comparing the articulation, we could also see a difference. In the Honig group, 44.8% of the patients had no specific VPI-related AD at the late postoperative control, 29.3% had one AD, 20.7% had two AD and 5.2% had three AD. In the Hynes group, none of the patients had an AD at the late postoperative control. The group of patients receiving Hynes ($n=4$) was too small to perform valid statistical analysis.

DISCUSSION

The common goal of the surgical techniques used in this study is to improve velopharyngeal function without compromising the patency of the upper airway.

Reviewing the outcome of speech surgery in the University Hospitals Leuven between August 2002 and August 2010, we found a normalization of NI in 42.4 % of patients after 12 months, while another 35.6 % had an improvement without normalization, to a level that we judge only noticeable by trained listeners (i.e. speech therapist; NI = 1). For articulation, we found a normalization of the AI in 48.4% of patients after 12 months, while another 17.7% had an audible and/or visible improvement without normalization, to a level that we judge only noticeable by trained listeners (i.e. speech therapist; AI = 1).

At 12 months postoperatively, surgery was successful (no or mild hypernasality as scored with the NI) in 46 of 59 patients or 78.0%. Taking into account the late improvement of seven patients, 90% of the patient population reached the desired speech result ($NI \leq 1$). In six patients or 10.2%, moderate hypernasality ($NI = 2$) persisted at their last control visit. Four of them were known with 22q11 deletion syndrome and the other two patients with the Pierre Robin sequence syndrome. These results are consistent with the results of Shprintzen et al. (normal postoperative speech assessment in 78%) and with the results of Peat et al., where

acceptable vocal resonance was achieved in 81% in patients who underwent a Honig velopharyngoplasty or a Hynes pharyngoplasty.[9,10]

We looked at prognostic factors that can explain the postoperative variation in outcome.

The speech outcome after surgery was significantly worse in patients with a diagnosis of 22q11 deletion syndrome than in patients without the syndrome at the late postoperative control. This result is comparable to the results of Widdershoven et al., where outcomes of hypernasality were also significantly better in the control group than in the 22q11del group, and to the results of Losken et al., where the revision rate, used as an indicator of success, was significantly higher in patients with 22q11del than in patients without 22q11del.[2,10] This is not unexpected since children with 22q11del have several intrinsic anatomic and physiologic characteristics that may contribute to the impairment of normal velopharyngeal closure: in addition to the possibility of having a true cleft palate, other factors that are thought to contribute to VPI in 22q11del patients are (1) pharyngeal muscle hypotonia, which results in reduced velar mobility, (2) platybasia (an obtuse angulation of the cranial base), which results in an increased distance from the palate to the posterior pharyngeal wall, (3) adenoid hypoplasia, which enlarges the pharyngeal gap, and (4) developmental delay, which results in a slower adjustment to the new anatomic situation after surgery.[11,12] This latter may explain the significant greater difference between the two groups at the late postoperative control as compared to the early postoperative control.

Other factors assumed to influence the success of velopharyngoplasty are the age of the patient at surgery (more successful in younger patients) and the amount of preoperative speech therapy (extensive preoperative therapy resulting in improved speech accuracy with fewer compensatory misarticulations postoperatively). In our study, we could not demonstrate an influence of the age at surgery or the amount of preoperative speech therapy on the outcome of surgery.

The velopharyngoplasty surgery can be performed as a primary surgery or as a secondary surgery (Figure 1). We found that the outcomes in the last group were significantly better at both the early and late postoperative control. The most reasonable explanation for the better outcome in de secondary velopharyngoplasty group is the fact that all the patients with the 22q11.2 deletion syndrome underwent a primary velopharyngoplasty, so there were no patients with VCFS in the secondary velopharyngoplasty group.

The Honig velopharyngoplasty and the Hynes pharyngoplasty were the most frequently performed procedures to treat VPI in the University Hospitals Leuven between 2002 and 2010. Based on our data, the latter seems as effective as the former, however, it should be mentioned that a clear difference in preoperative severity of VPI could be seen between the groups, with the Hynes group consistently having a milder VPI than the Honig group. This selection bias is probably responsible for the postoperatively observed differences. Taken also the low number of patients who underwent a Hynes pharyngoplasty into account, it is not possible to make a definite conclusion about the effectivity of the Hynes technique. During the last years, besides the Hynes pharyngoplasty, also intravelar veloplasty and buccinator flap were gradually added to the armamentarium, so as to increasingly individualize the VPI treatment.[13] This evolution will of course be the subject of future research.

We reviewed surgical complications. The main concerns when performing any type of velopharyngoplasty is to avoid airway obstruction and sleep apnea syndrome. 14% of our patients presented with mild to moderate hyponasality early postoperatively and 11.3%

had persistent snoring after the surgery, but in none of the patients sleep apnea was noted. Two patients with persistent snoring were referred for a polysomnography, where sleep apnea was excluded.

Limitations of this study are of course the retrospective nature, resulting in missing values, and the lack of prospective speech recordings for blinded independent speech assessment. The limited number patients treated with the Hynes palatoplasty do not allow a firm conclusion in comparison to the Honig technique.

Since 2010, standardized audio and video recordings of speech were implemented to evaluate the speech results more objectively in the future.

CONCLUSION

After velopharyngoplasty, a good speech outcome in terms of hypernasality (no or mild hypernasality at the postoperative control at 12 months) was found in 46 of 59 patients, further improving in another seven patients to finally reaching a success rate of 90%. In the same way, a statistically significantly improved articulation index was observed. In patients with a diagnosis of 22q11del, these outcomes were significantly worse. In our series and using our techniques, obstructive sleep apnea syndrome does not seem an issue following velopharyngoplasty.

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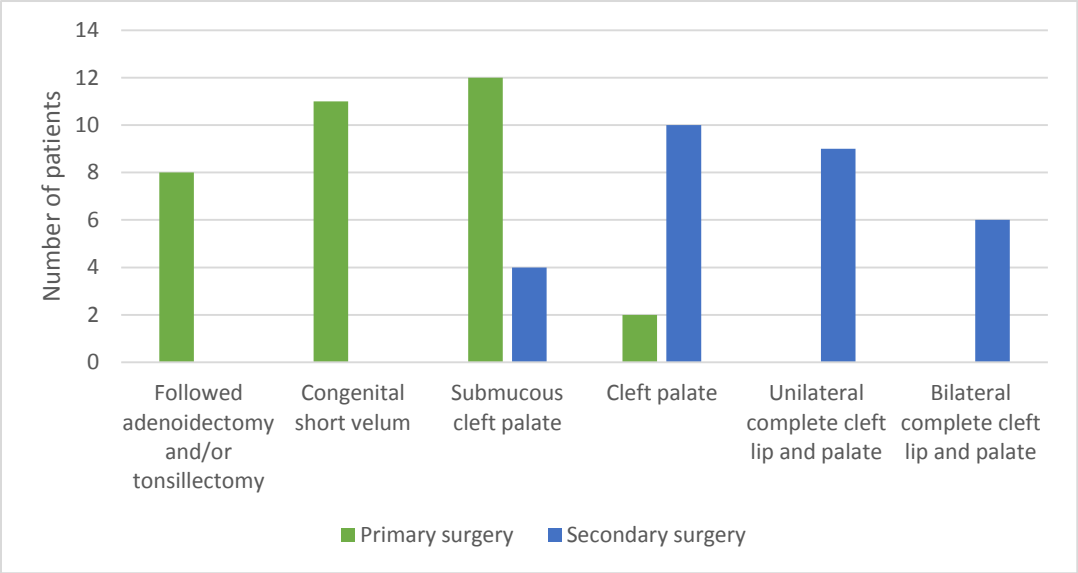

FIGURE 1 Distribution of patients based on cleft type with a distinction between primary and secondary velopharyngoplasty.

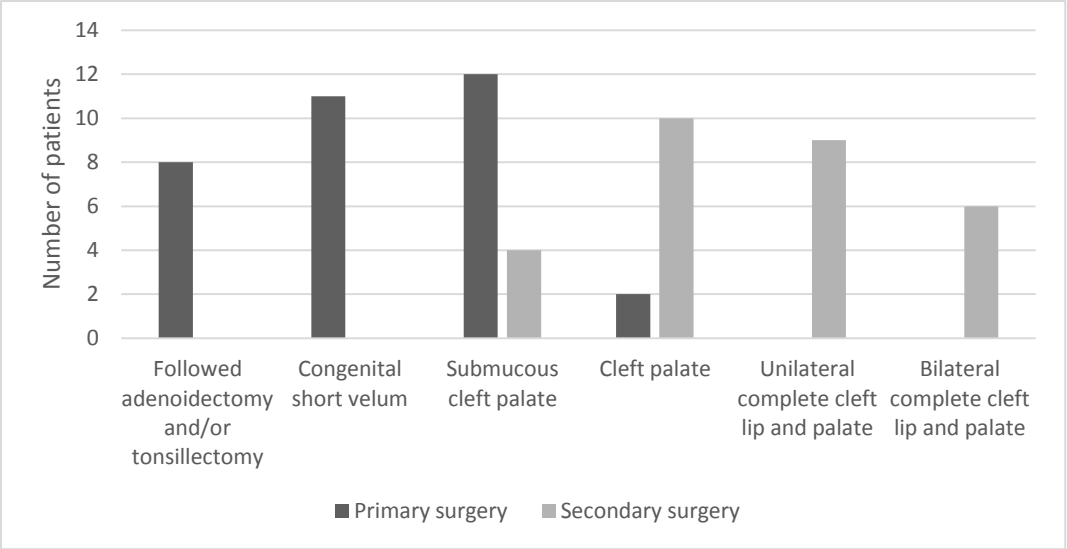

FIGURE 1 Distribution of patients based on cleft type with a distinction between primary and secondary velopharyngoplasty.

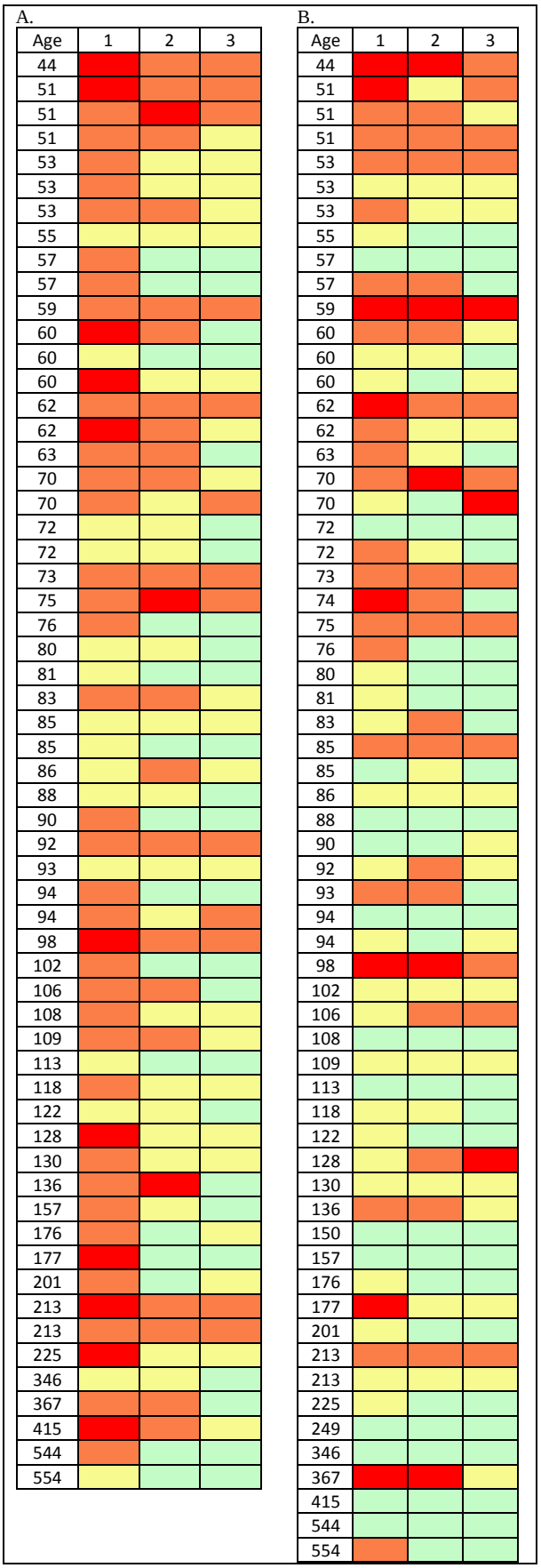

FIGURE 2 The results; preoperatively (1), 2 months postoperatively (2) and 12 months postoperatively (3); of the nasality index (A) and articulation index (B) ordered by age. Green indicates a score of 0, yellow a score of 1, orange a score of 2 and red a score of 3.

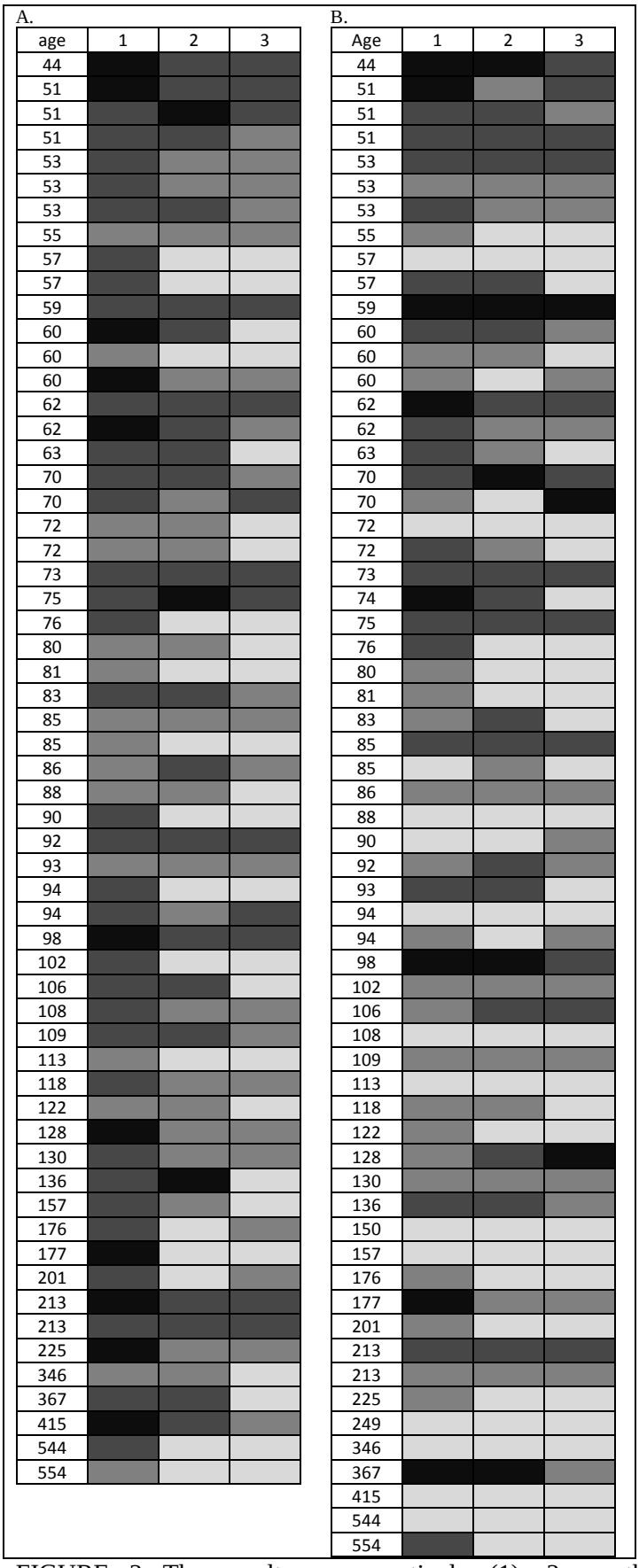

FIGURE 2 The results; preoperatively (1), 2 months postoperatively (2) and 12 months postoperatively (3); of the nasality index (A) and articulation index (B) ordered by age. The grey scales indicate the score, going from light grey (= score 0) till black (= score 3).

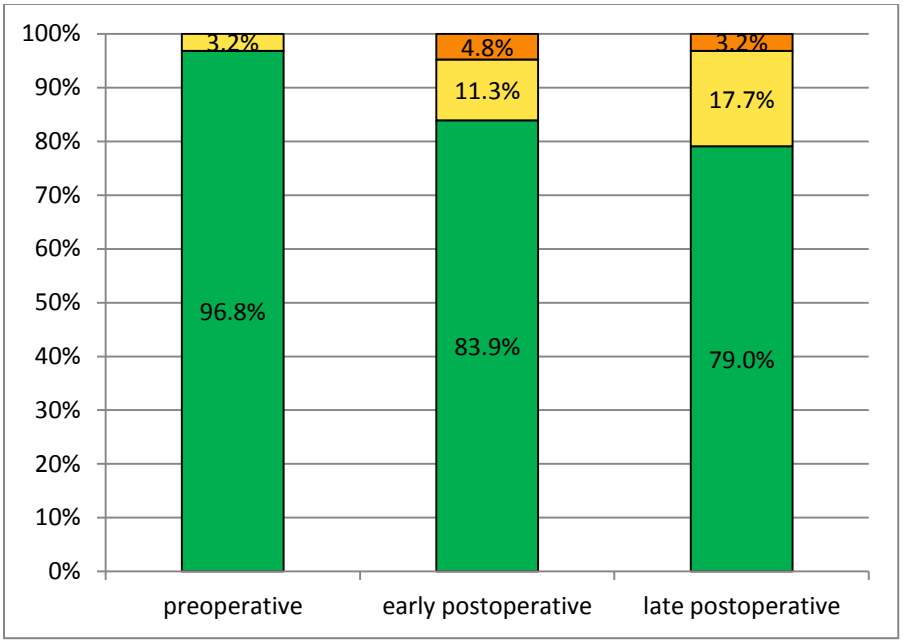

FIGURE 3 Hyponasality preoperatively, early postoperatively and late postoperatively. Green indicates a score of 0, yellow a score of 1, orange a score of 2 and red a score of 3.

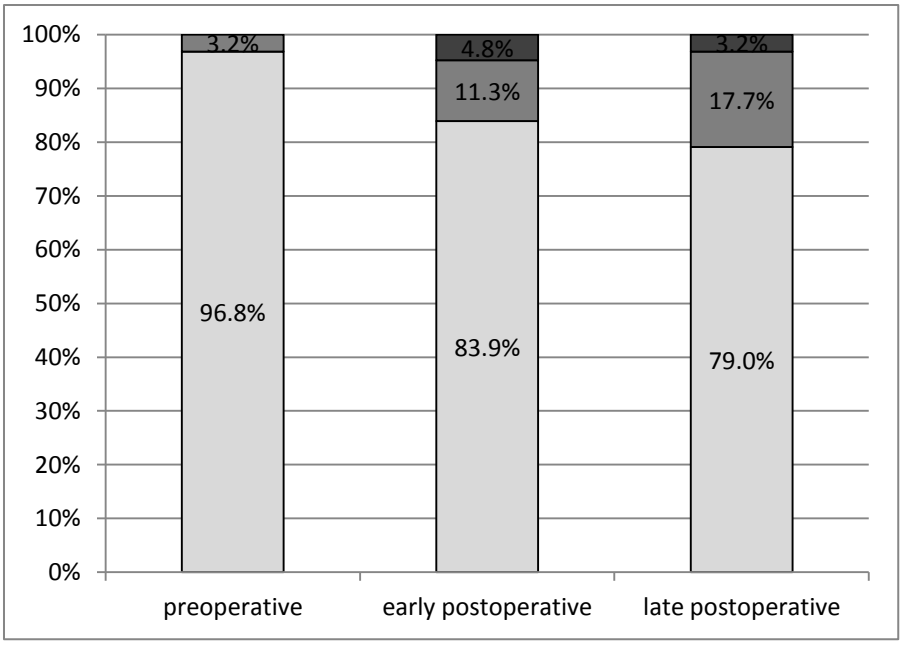

FIGURE 3 Hyponasality preoperatively, early postoperatively and late postoperatively. The grey scales indicate the score, going from light grey (= score 0) till black (= score 3).

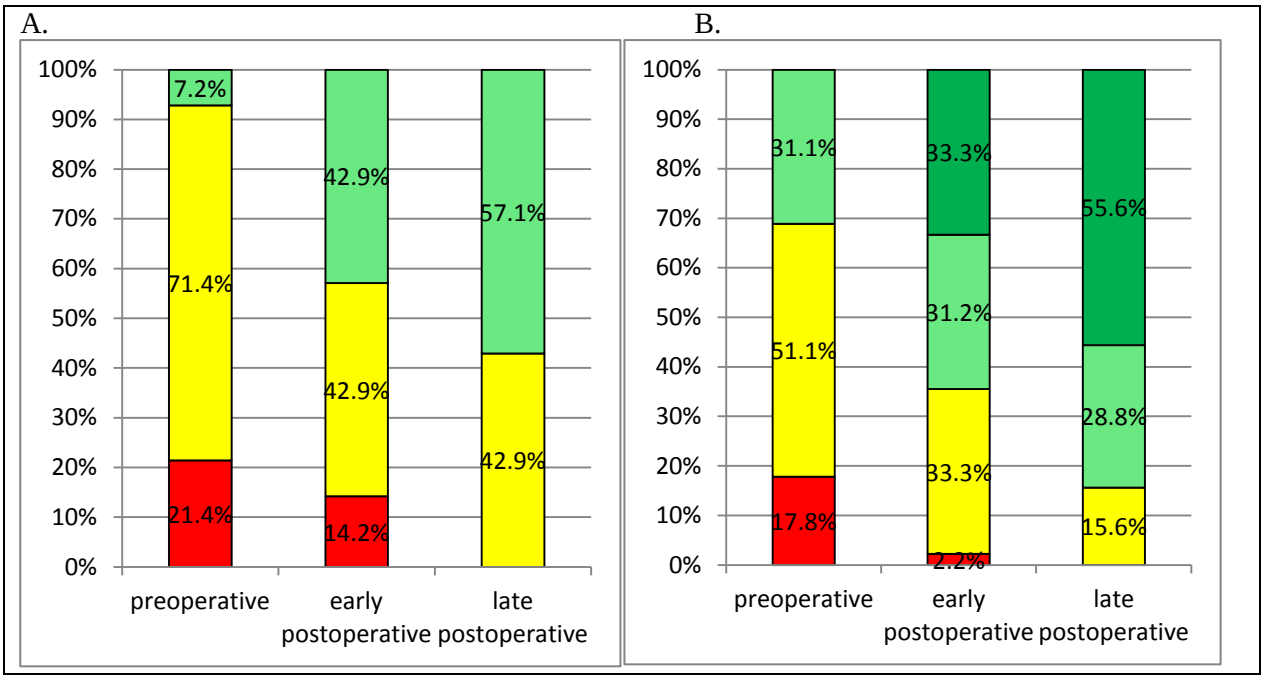

FIGURE 4 Nasality index (NI) in the 22q11del group (A) and the non-22q11del group (B) preoperatively, early postoperatively and late postoperatively. Red indicates a score of 3, yellow a score of 2, light green a score of 1 and dark green a score of 0.

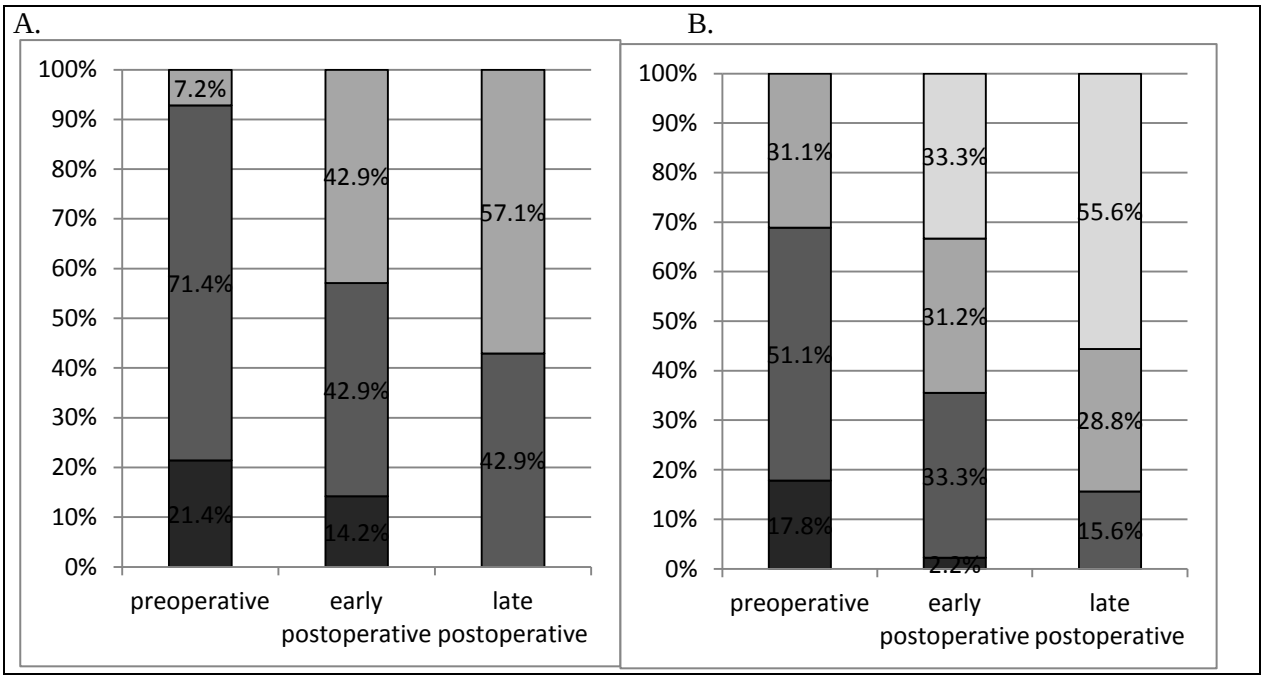

FIGURE 4 Nasality index (NI) in the 22q11del group (A) and the non-22q11del group (B) preoperatively, early postoperatively and late postoperatively. The grey scales indicate the score, going from light grey (= score 0) till black (= score 3).

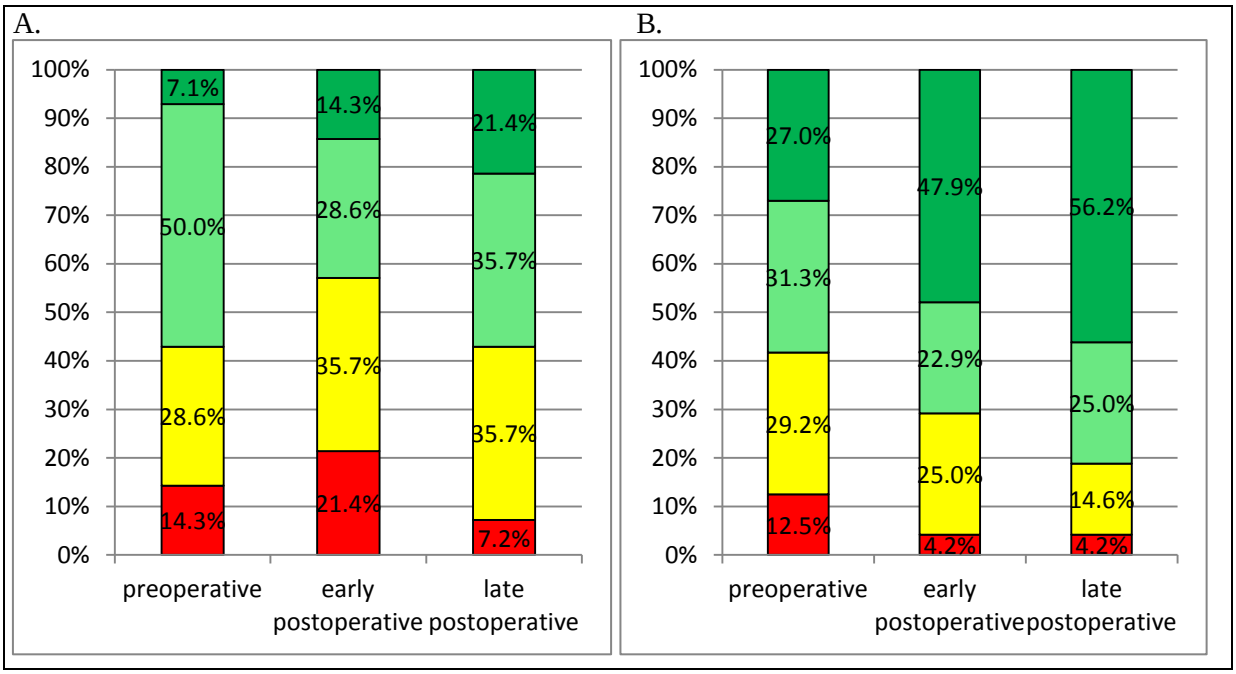

FIGURE 5 Articulation index (AI) in the 22q11del group (A) and the non-22q11del group (B) preoperatively, early postoperatively and late postoperatively. Red indicates a score of 3, yellow a score of 2, light green a score of 1 and dark green a score of 0.

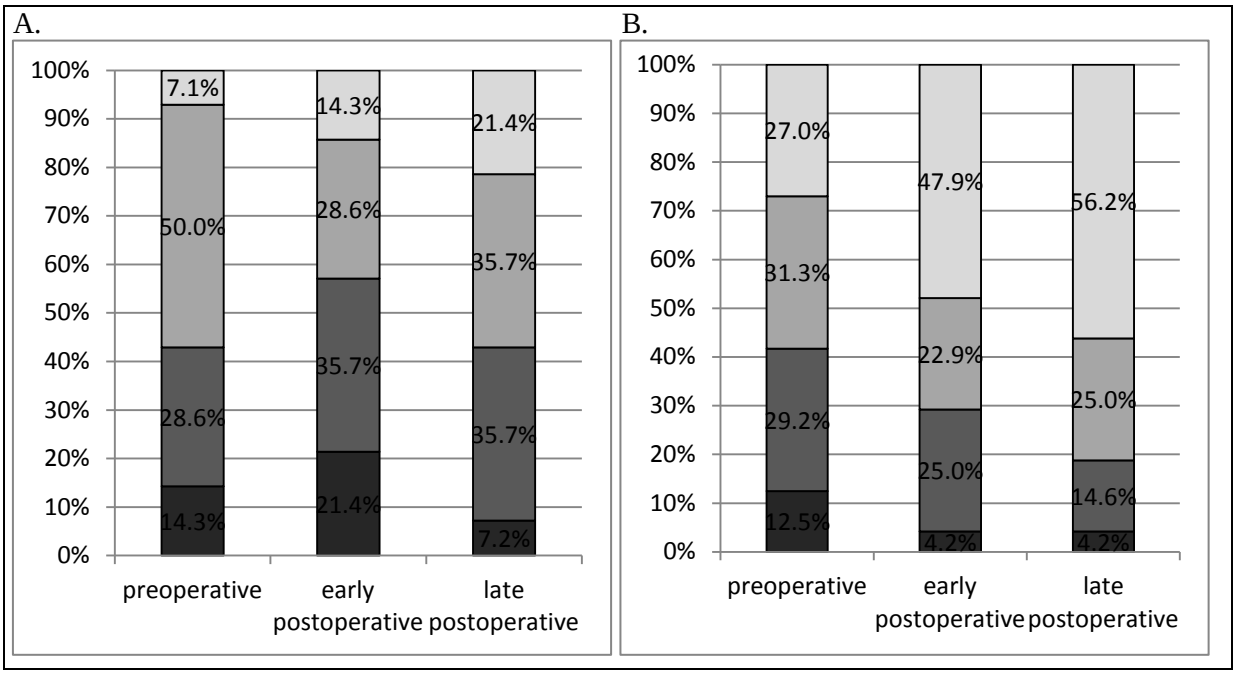

FIGURE 5 Articulation index (AI) in the 22q11del group (A) and the non-22q11del group (B) preoperatively, early postoperatively and late postoperatively. The grey scales indicate the score, going from light grey (= score 0) till black (= score 3).

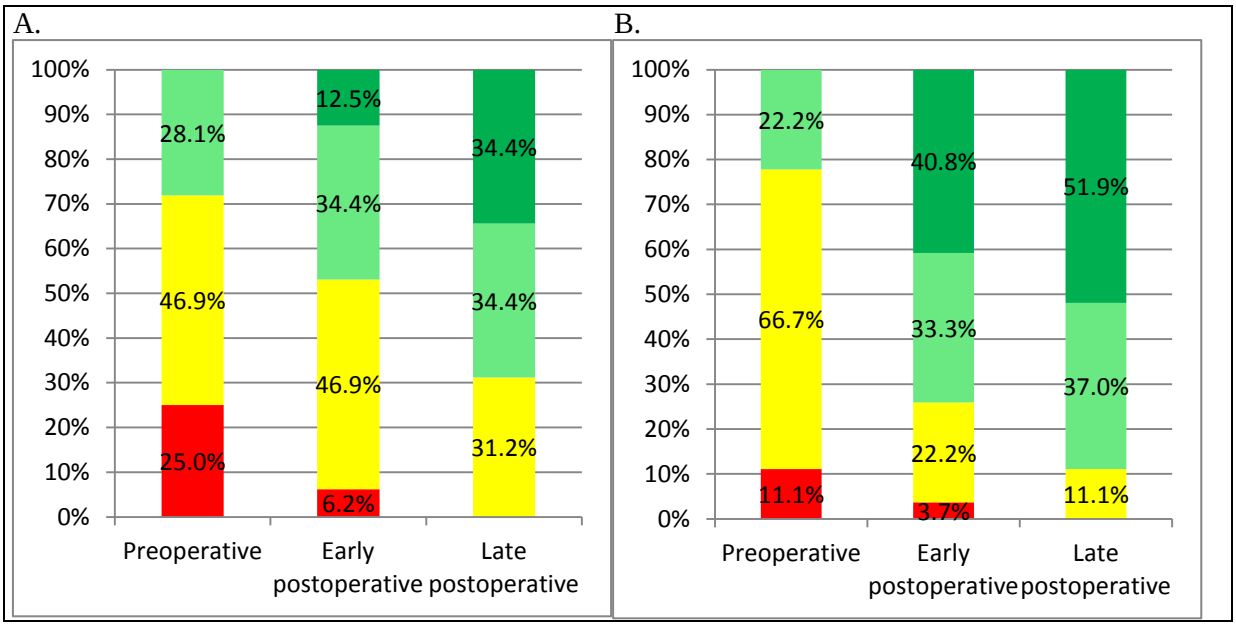

FIGURE 6 Nasality index (NI) by the primary pharyngoplasty (A) and the secondary pharyngoplasty (B) preoperatively, early postoperatively and late postoperatively. Red indicates a score of 3, orange a score of 2, yellow a score of 1 and green a score of 0.

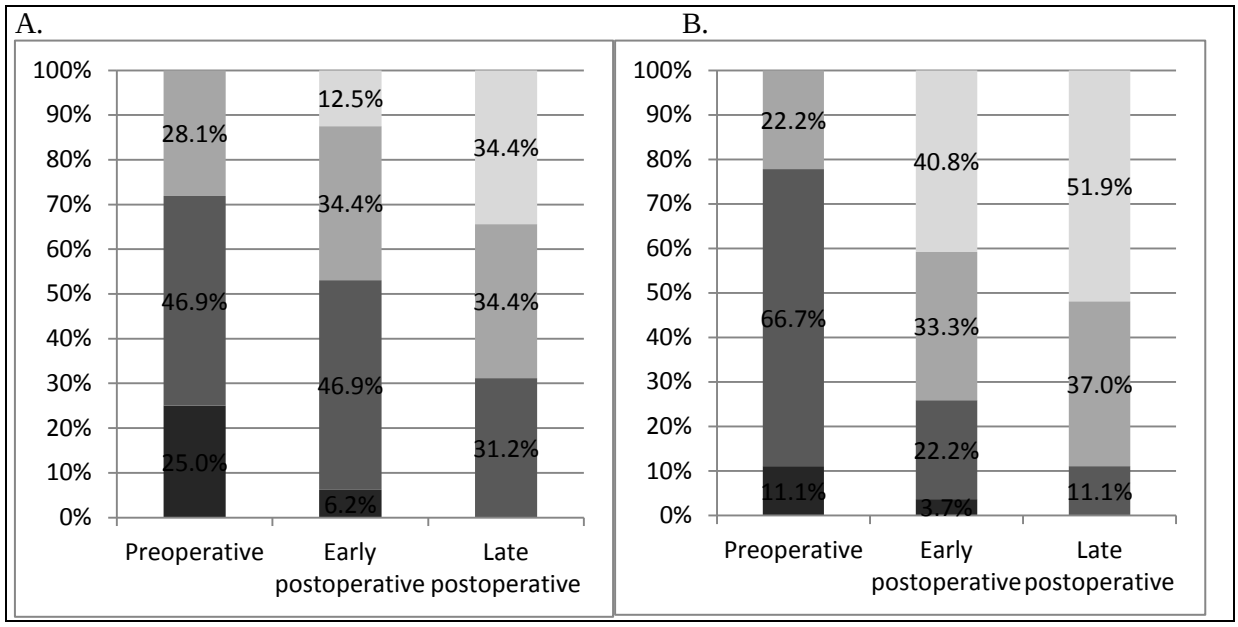

FIGURE 6 Nasality index (NI) by the primary pharyngoplasty (A) and the secondary pharyngoplasty (B) preoperatively, early postoperatively and late postoperatively. The grey scales indicate the score, going from light grey (= score 0) till black (= score 3).